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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in and relating to the Steam Reformation of Light Hydrocarbon Feeds

We, FOSTER WHEELER LIMITED, a British Company of Foster Wheeler House, Chapel Street, London, N.W.1, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to the steam reformation of light hydrocarbons. More particularly it relates to the production of hydrogen and carbon monoxide by steam reformation of a light hydrocarbon feed by heating it in the presence of steam and a catalyst.

Steam-reforming of light hydrocarbons for the production of hydrogen and carbon monoxide is well-known. The hitherto used processes for carrying out the reaction which involves mixing the hydrocarbon feed and steam and passing the mixture through a number of reaction zones, often constituted by a bank of parallel tubes disposed within a furnace chamber, suffer from the disadvantage that a quantity of steam considerably in excess of that required to react with the hydrocarbon has to be passed with the hydrocarbon feed over the catalyst to prevent excessive coke formation.

Indeed, when the hydrocarbon feed is composed of paraffinic hydrocarbons heavier than methane, the steam requirements are such as to make the carrying out of steam-reformation on an industrial scale barely, if at all, economic.

It is the object of the invention to provide a process which keeps both the steam requirement and the coke formation to a minimum.

In accordance with the invention the steam is passed serially through two or more catalyst-containing reaction zones to each of which is supplied a portion of the hydrocarbon feed. The reaction products and unconverted reactants from each zone are passed to its adjacent downstream zone. The reaction will usually be performed at superatmospheric pressure.

It is found that the total steam requirements i.e. the quantity of steam required to react with the hydrocarbon feed plus the quantity of steam required to keep the degree of coking within acceptable limits, compares favourably with the total steam requirements of the conventional processes, especially when the hydrocarbon feed is composed of, or consists largely of, paraffinic hydrocarbons heavier than methane.

Apparatus in accordance with the invention for carrying out the process can comprise two or more catalyst-containing reaction zones connected together in series and positioned within a furnace so that reactants in the zones are heated on passage through them, means connected to a source of steam for supplying steam to the first of the zones so that if flows serially through the reaction zones, and means for feeding a portion of the hydrocarbon feed to each of the reaction zones, the reaction products and unconverted reactants from each reaction zone being arranged to pass to the adjacent downstream reaction zone and to mix with the portion of the hydrocarbon feed added to that reaction zone.

In order that the invention may be more fully understood, an example of the process and one embodiment of apparatus in accordance with it will now be described with reference to the accompanying schematic drawing.

The drawing shows in section a furnace 10 having a furnace chamber 12 through which extend two straight tubes 14 and 16. The furnace is equipped with burners 18 arranged to direct their flames against the side walls 20 of the furnace which are lined with refractory material. Heat is radiated from the walls 20 into the furnace chamber 12, thus heating the tubes 14 and 16 whilst the waste combustion gases are discharged from the chamber 12 through a flue 22.

The tubes 14 and 16 form two reaction zones in which the steam reformation reaction

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is to be carried out, and they are filled with a suitable reformation catalyst 24 such, for example, as a Group VIII metal e.g. nickel or iron or Group VIII metal oxide on a support. Examples of catalysts are nickel oxide, nickel-thoria-magnesia, nickel - alumina - magnesia, nickel-magnesia, nickel on carbon, nickel-alumina and cobalt molybdate on alumina.

In operation the hydrocarbon feed to be reformed is supplied, preferably at superatmospheric pressure from a source (not shown) through a line 26. At a point 28, the line 26 divides into a line 30 which takes a portion of the feed supplied through the line 26 and a line 32 which takes the remainder of the feed. The line 30 leads at 34 into a line 36 through which steam from a suitable source (not shown), and also preferably at superatmospheric pressure is supplied to the upper end of the tube 14. The resulting steam and hydrocarbon mixture thus conducted to the tube 14 passes down this tube in the presence of the catalyst 24, and is heated by the heat radiated from the furnace walls 20, and the steam and hydrocarbon react to produce hydrogen and carbon monoxide.

The reaction products, steam, and any unconverted hydrocarbon, are led from the lower end of the tube 14 by a U-bend 38 into the lower end of the tube 16. At a point 40 in their path of travel from the tube 14 to the tube 16, these gases are admixed with that portion of the hydrocarbon feed passed into the line 32. The gas mixture now containing fresh hydrocarbon feed passes up the tube 16 where further carbon monoxide and hydrogen are produced. The mixture of gases is led from the upper end of the tube 16 through a line 42 for further processing, storage, or use, as the case may be.

In practice, there will invariably be many more than the two reaction zones shown in the drawing, but whatever the number of zones, the steam is passed serially through the zones and a portion of the hydrocarbon feed is supplied to each zone to mix, in each zone except for the first, with the reaction products and unconverted reactants passed to the zone from its adjacent upstream zone, in the manner described above for the two-zone apparatus shown in the drawing.

Also, instead of single tubes as shown in the drawing, each zone will preferably be composed of a cluster of parallel tubes connected at their ends to inlet and outlet manifolds.

As has already been mentioned, it is found that the total steam requirements for the process of the invention compare favourably with those for the conventional reformation processes, and if, as is shown in the drawing, the apparatus in which the reaction is performed has a furnace, in most cases sufficient steam can be supplied from a waste heat boiler heated only by the waste combustion gases from the furnace. In this case, the process is economically very attractive. It will, however, be understood that instead of the apparatus having means for heating the reactants as they are passed through the reaction zones, the reactants can be preheated before they reach those zones.

The process of the invention is applicable to all light hydrocarbon feeds. Best conversions to hydrogen and carbon monoxide are however obtained if the feed is composed of a paraffin having up to 10 carbon atoms, petroleum naphtha, gasoline or diesel oils, or mixtures thereof.

If a particular relationship of carbon monoxide and steam is desired, carbon dioxide can be added to the feed.

WHAT WE CLAIM IS:—

1. A process for the production of hydrogen and carbon monoxide by steam reforming a light hydrocarbon feed by heating it in the presence of steam and a catalyst, in which the steam is passed serially through two or more catalyst-containing reaction zones, to each of which is supplied a portion of the hydrocarbon feed, the reaction products and unconverted reactants from each zone being passed to its adjacent downstream zone.

2. A process as claimed in Claim 1 carried out at superatmospheric pressure.

3. A process for the steam-reforming of a light hydrocarbon feed substantially as herein described with reference to the accompanying drawing.

4. A process as claimed in Claim 1 carried out in an apparatus comprising two or more catalyst-containing reaction zones connected together in series and positioned within a furnace so that reactants in the zones are heated on passage through them, means connected to a source of steam for supplying steam to the first of the zones so that it flows serially through the reaction zones, and means for feeding a portion of the hydrocarbon feed to each of the reaction zones, the reaction products and unconverted reactants from each reaction zone being arranged to pass to the adjacent downstream reaction zone and to mix with the portion of the hydrocarbon feed added to that reaction zone.

5. A process as set forth in Claim 4 in which each of the reaction zones comprises a tube disposed within the furnace.

6. A process as set forth in Claim 4 in which each of the reaction zones comprises a cluster of parallel tubes connected at their ends to inlet and outlet manifolds and disposed within the furnace.

7. Hydrogen and carbon monoxide when prepared by a process as claimed in any of claims 1 to 6.

Dated this 8th day of August, 1963.
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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*